

EXPLORING THE EFFECTIVENESS OF CHEMISTRY-THEMED BOARD GAMES IN CLASSROOM INSTRUCTION ON STUDENTS' ACHIEVEMENT IN CHEMICAL EQUILIBRIUM

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Abstract

The students' consistent low achievement in internal and external examinations warranted the study. Thus, the purpose of the research is to explore the effectiveness of chemistry-themed board game instruction on students' academic achievement in chemical equilibrium in Agbani Education Zone. The study was guided by two research questions and three research hypotheses. The study employed a pretest-posttest non-equivalent control group design. 1,253 SS2 Chemistry students made up the study's population. A combination of random and purposive sampling procedure was used to select 100 students'. While the control group received instruction via lectures, the experimental group was taught using chemistry-themed board game based teaching strategy. The Chemical Equilibrium Achievement Test (CEAT) was the instrument used for data collection, and its reliability index was evaluated using Kuder-Richardson's formula-20 which yielded coefficient of 0.89. The mean, standard deviation, and analysis of covariance were used to analyze the data. The finding amongst others showed that students exposed to the chemistry-themed board game based teaching strategy outperformed their peers who received instruction on lecture method. Based on the findings, it was recommended that Chemistry teachers should integrate board game based teaching strategy when teaching chemistry.

Keywords: Chemistry-themed-board-game, Chemistry, Academic achievement, Gender and Chemical equilibrium.

Introduction

Chemistry is the scientific study of composition, characteristics, and behavior of matter in a given environment. Chemistry as a science subject studies atoms and how they interact with one another, especially the characteristics of chemical bonds. In school science curricula designed for pupils thinking about a career in science, chemistry is a major subject. According to Omoniyi and Torru (2018), this field of study connects other natural sciences including physics, geology, and biology. Eze and Omeje (2023) defined Chemistry as a branch of science that deals with the identification of the substance of which matter is composed. According to Obialor and Chukwuagu, (2022) Chemistry has been identified as a very important science subject and its importance in specific and technological development of any nation has been widely reported. It was as a result of the recognition given to Chemistry in the development of man and his environment (the nation) that it was made a core subject among the physical sciences and a prerequisite for studying many sciences related courses such as medicine, pharmacy, biochemistry, nursing, engineering, industrial Chemistry, anatomy etc. in Nigerian institutions. Chemistry being an important subject in the school science curriculum is part of

peoples' everyday life, everything scientist do is Chemistry. Chemical reactions occur when we breathe, eat or read. Chemistry as a branch of science has helped in the development of the following sectors; agriculture thereby, providing food and making agricultural activities easier and faster, clothing through textile industries, medicines, transportation, hygiene, control of air and water pollution, cement industries, paints, pigments, plastics, petroleum, sugar, paper and even education. Learning Chemistry allows students to learn about scientific method and gain skills in critical thinking, deductive reasoning, problem solving and communication (Eze & Omeje, 2023). Teaching Chemistry effectively to students at a young age can increase students' achievement and provide them with many transferable skills that can be applied to many careers, (Obialor & Chukwuagu, 2022). Chemistry as a subject has an interesting application in the chemical equilibrium concepts of chemistry.

Chemical equilibrium is a state of stability in a chemical system. Chemical equilibrium is defined as a state of system where there is no observable change in the properties and state of the system in relation to time (Ababio, 2021). Chemical equilibrium is a unique concept in chemistry as it bridge greater gap in real life applications. For instance, one of the most prominent applications of chemical equilibrium is in the Haber process, which synthesizes ammonia used in fertilizers. By optimizing conditions (e.g., pressure and temperature), industries can shift the equilibrium towards ammonia production, increasing yield. Ihechukwu (2020), noted that presence of ammonia in a fertilizer is essential for large scale production of farm produce. Fertilizer is a veritable implement for farm production; which when harnessed will solve the problem of hunger especially in Nigeria with high cost of living. In drug formulation, understanding how drugs bind to receptors involves equilibrium concepts (Matsumura, 2018). The efficacy of a drug can depend on its ability to establish a favorable equilibrium between its active form and its inactive form (O'Halloran, 2017). The equilibrium between carbon dioxide (CO_2), bicarbonate (HCO_3^-), and carbonate (CO_3^{2-}) in oceans is crucial for marine ecosystems. Changes in temperature and pH can shift this equilibrium, impacting ocean health and contributing to issues like ocean acidification. In the natural cycle of photosynthesis and respiration, the equilibrium between carbon dioxide, oxygen, and glucose illustrates the balance necessary for life. Plants through photosynthesis, convert CO_2 and water into glucose and oxygen; while animals and humans respire, consuming oxygen and releasing CO_2 , maintaining an essential equilibrium in the ecosystem. Again, the vest application of chemical equilibrium has found names in human life especially the regulation of oxygen and carbon dioxide in human bodies that relies on the concept of chemical equilibrium. Hemoglobin binds to oxygen in the lungs and releases it in tissues, maintaining a dynamic balance essential for cellular respiration. According to Daubenfeld and Zenker (2015), catalysts are often used to shift equilibrium toward the desired products more efficiently. This principle is crucial in various chemical manufacturing processes, including the production of plastics and synthetic materials. The underpinning roles of chemical equilibrium and thermochemistry to national and human development could not be commensurate with the students' achievement and success in the concepts.

Despite the importance and relevance of chemistry to national development, students' academic achievement in the subject has been so abysmal and cannot measure up with its standard in the nation. Academic achievement is defined as the scholastic standing of a student at a given moment as explained in term of the grades and performance on an educational achievement test and cumulative indicators such as educational degrees and

certificates. Onah, (2023) further defined academic achievement as performance outcomes that indicate the extent to which a person has accomplished specific goals that were the focus of activities in instructional environments; specifically, in schools, colleges and universities. Achievement is a measure of output and the main outputs in education are expressed in terms of learning, that is, changes in behaviors, knowledge, skills and attitudes of individuals as a result of their experiences within the schools' system. In the context of this work, academic achievement is taken as the student's overall performance in the external WASSC and/or NECO examinations (Onah, 2023). Record of students' achievement at Senior School Certificate Examination (SSCE) in chemistry conducted by West African Examination Council (WAEC) has been too poor. This ugly situation was confirmed by the Chief Examiners' Report of West African Examinations Council (WAEC). Record of students' performance at Senior School Certificate Examination (SSCE) in chemistry conducted by West African Examination Council (WAEC) showed that between 2015 to 2023, less than 50% of the students who enrolled for chemistry obtained credit level pass and above to secure admission into the university in order to pursue courses that require chemistry. The failure trends continued in 2015, 2017, 2020 2021, and 2022 (47.83%, 41%, 43.5%, 46.83 & 36% respectively) with an improved achievement in 2016, 2018, 2019 and 2023 (54%, 62.4% 55.6%, & 68.3% respectively) (Field Survey, 2024). In general, this cannot be considered an acceptable achievement as many have lamented that achievement of Nigeria students in chemistry at the Senior School Certificate Examination (SSCE) has been generally not so good (Eze and Omeje, 2023). Even the WAEC chief examiners report in chemistry specifies areas of students' weakness as chemical equilibrium and thermochemistry concept of chemistry. Also a study conducted by Onwu (2017) on the Identification of Major Areas of Students' Difficulties in Chemistry Syllabus showed that students' finds the following topics difficult; electrolysis, redox reaction, periodic table, Acid, Base and Salt, chemical equilibrium and thermochemistry. The WAEC Chief Examiner observed that students' were unable to answer chemistry questions in chemical equilibrium. The examiners based their findings on their inability to interpret question with application of the concepts. The Chief examiners noted that students performed poorly in the subject because teachers usually use lecture method which does not give room for inferred application. Based on the observed weaknesses, the WAEC Chief Examiners (2022) recommended that: Teachers should attend coordination exercises during marking to learn the current trend in teaching and learning of chemistry; Classroom instructions should be backed up with appropriate teaching strategy that will enhance student's positive attitude towards chemistry; Teachers should expose students to more class work and assignments; Teachers should upgrade their teaching skills to embrace modern methodology like cooperative learning strategy and inquiry based learning; Qualified chemistry graduate should be recruited by the government; Students should be more dedicated to their studies; Students should be encouraged to buy chemistry textbooks; Students should be more dedicated to their studies. According to Eze and Omeje (2023) the teachers poor instructional approach like lecture method of instruction; has been accounted for students' poor achievement in chemistry in particular and science in general.

Lecture method is the method of teaching that is concerned with valuable presentation of concepts and ideas to the students through talk and chalk pedagogy. It enhances quality presentation of concepts in science and adequate coverage of syllabus. In this approach, curricular activities rely heavily on textbooks and workbooks. Most teachers adhere to it even when students do not understand the important concepts (Onah, 2022). Hence, it does not

promote meaningful learning. The features of lecture method includes: Excessive talking, copying of notes and rote learning of textbooks and materials adopted by science teachers in Nigeria. Again, conventional lecture method incorporate expository method rather than inquiry methods of instruction which does not predispose students to hands-on-minds-activity, for arousal of the learners' enthusiasm in the teaching learning process and interest in science (Onah & Achufusi, 2022). According to Omeje (2024) poor instruction of lecture method is also responsible for poor achievement among chemistry students in all level of education in Nigeria. This study is set to explore the effectiveness of chemistry-themed board games on students' academic achievement in secondary school Chemistry concept of chemical equilibrium.

Game-based learning is the creation of an exciting adventure to learn science. Game based learning is not just a way of creating games for students to play but to stimulating learning experience through content creation. Instead, their purpose should be to design learning activities that introduce or explain concepts in an exciting manner. According to Ookman (2016), game-based learning enhances students' ability to find out the necessary information for themselves. The confusion between leisure games and educational games arouse due to the fact that both are used synonymously (Hamari, Shernoff, Rowe & Collier (2016). This confusion leads to inappropriate use of leisure games in classroom when they do not follow the principles of good learning design, taking in mind learning goals. Instead, they have being used as a break in the learning. According to Daubenfeld and Zenker (2015), games should not serve only as an entertaining tool, but instead they should foster active engagement of all students who will tend to master the material while playing and having fun. Games must be well-planned. Always think of their didactic function and implication in the classroom. Play is valuable in the development of creativity and inadvertent learning (Hamari, Shernoff, Rowe & Collier (2016). But discussion is the key factor in improving the problem-solving skills, clarification and correction of potential misunderstandings and misconceptions. Therefore, teachers should discuss with the entire class how to arrive at correct answer or correct understanding of the process or a phenomenon. Discussion is an important segment in developing thinking and evaluation and, if appropriately guided, it always produces results. Game-based learning can be employed in chemistry teaching either as a way of entry behavior or elucidation of the concepts (Stojanovska, & Velevska, 2018). Again it can serve as a medium of lesson development or a means of lesson review (Daubenfeld, & Zenker, 2015). It means that they can be used as an introduction to the new material or as a platform to revise the material and practice skills that have been previously taught. Review sessions enable students to reflect on the material, practice and have fun (Kavak & Yamak, 2016; Stringfield & Kramer, 2014). Therefore, this study seeks to examine the effectiveness of chemistry-themed board games on students' academic achievement in secondary school Chemistry concept of chemical equilibrium in Agbani Education Zone, Enugu State, Nigeria irrespective of gender.

Gender has been noted by researchers over the years as having impact on achievement and retention in chemistry and its related disciplines (Onah & Achufusi, 2022). Onah and Anamezie (2022) even stressed that science, technology and their related disciplines are male-reserved while Art and Humanities are female reserved. This belief makes boys appear to have a natural positive attitude towards science and technical subjects while girls show more inclination to Arts and Humanities. The problem is even compounded by the fact that most science educators give masculine outlook to science subjects such as chemistry and physics

(Omeje, 2024); encouraging females to go rather for biology, agricultural science and home economics which they consider to be more female-friendly science subjects. Some other researchers (Daubenfeld, & Zenker (2015), Hamari, Shernoff, Rowe & Coller (2016), Khan, Gul, Hussain & Yousaf, 2022; Onah, 2023) opined that gender has no influence on students' achievement in the sciences. All these and related treatments make girls have phobia for science and science-related subjects which definitely affect their future career-choice and eventual achievement. Due to lack of consensus regarding the issue of gender and science and more importantly to capture the interest of girls, and consequently improve their achievement and in chemistry and other science related carriers, there is a need therefore to try such innovative strategy as chemistry-themed board games to see what effect it will have on achievement of male and female students in the sciences especially chemistry.

Statement of the Problem

Despite the positivisms of Chemistry to mankind, students' achievement, and overall performance in secondary schools in Nigeria has been so poor and abysmal. This problem poses pertinent educational issue to the general populace that requires urgent attention. In view of this, many researchers in recent time are interested in the factors affecting academic achievement and in Chemistry in particular and sciences in general with a view to finding solutions to the problems of poor academic achievement. Studies on students' academic achievement have mostly pointed out that effective and innovative teaching approaches are the major variable that enhances academic achievement, yet they have received very little attention if any, in the literature of Agbani Education Zone of Enugu State. In view of the on-going, the present study seeks to explore the effectiveness of chemistry themed game based instruction in chemistry on academic achievement and hence deemed it very important to find out the if scaffolding teaching strategy can enhance students' academic achievement in Chemical equilibrium concepts of Chemistry students in the Zone. Therefore, the worries about the study are set to provide solution to the problem of the study which is stated in a question form, "What is the effectiveness of chemistry-themed board games on students' academic achievement in secondary school Chemistry concept of chemical equilibrium in Agbani Education Zone.

Purpose of the Study

The main purpose of this study was to examine the effectiveness of chemistry-themed board games on students' academic achievement in secondary school Chemistry concept of chemical equilibrium in Agbani Education Zone of Enugu State. Specifically, the study sought to determine the:

- Difference between the mean achievement and standard deviation scores of students taught Chemical equilibrium using chemistry-themed board games and those taught Chemical equilibrium using lecture method.
- Difference between the mean achievement scores of male and female students taught Chemical equilibrium using chemistry-themed board games.
- Interaction effect of chemistry-themed board games and gender on students' achievement in Chemical equilibrium.

Research Questions

The following research questions were developed to guide the study:

1. What is the difference between the mean achievement and standard deviation scores of students taught Chemical equilibrium using chemistry-themed board games and those taught Chemical equilibrium using lecture method?
2. What is the difference between the mean achievement scores of male and female students taught Chemical equilibrium using chemistry-themed board games?

Research Hypotheses

The following research hypotheses were raised and test at .05 level of significance.

H₁: There is significant difference in the mean achievement scores of chemistry students' taught chemical equilibrium using chemistry-themed board games and those taught with lecture method.

H₂: There is significant difference in the mean achievement scores of male and female chemistry students' taught chemical equilibrium using chemistry-themed board games.

H₃: There is significant interaction effect of chemistry-themed board games and gender on the achievement of chemistry students'.

Method

The study adopted a pretest – posttest quasi-experimental research design, specifically non-equivalent control groups. A pretest – posttest quasi-experiment is an experimental design where randomization of assignment of subjects to experimental and control groups is not possible (Nworgu, 2018). The design was considered most appropriate for the study because intact classes were used to avoid disruption of normal class lesson in the sampled schools. The study was carried out in Agbani Education Zone, located East of Enugu State, Nigeria. Enugu State has six Education Zones which include: Enugu, Awgu, Agbani, Nsukka, Obollo-Afor and Udi. Agbani Education Zone consists of three local government areas; namely: Enugu South, Nkanu East and Nkanu West local government area. The area has the first indigenous tertiary institution of the state which is Enugu State University of Science and Technology, Agbani (ESUT). The area is predominantly semi-urban in nature with basic amenities such as good roads, hospitals, electricity, schools and markets. Most people living in the zone were civil servants, students, traders and many farmers. The researcher chose Agbani Education Zone due to the fact that most of the secondary schools have qualified chemistry teachers, laboratories and instructional materials and yet students experience difficulties in answering questions in chemistry in their external examinations which was evident in their final achievement scores and grades in WAEC results hence the need for the study in the area. Therefore, this research will help the teachers to integrate game based instructional strategy in teaching chemistry which will in turn enhance good academic achievement. The population for the study consisted of 1,253 SS II Chemistry students in all the 44 public schools in the study area. One hundred (100) SS II Chemistry students (49 males & 51 females) drawn through multi-stage sampling approach from two co-educational secondary schools in Enugu south Local Government Area of Enugu State were used for the study. In stage one, simple random sampling technique was used to select Enugu south Local Government Area. In second stage, purposive sampling was used to select two co-educational schools in the local government area based on the existence of well-equipped chemistry laboratories and experienced chemistry teachers with teaching qualification in the schools. Simple random sampling technique (precisely balloting) was next used to assign experimental and control

treatments to the schools. The technique was used so as to provide classes where boys and girls work together under the same classroom environment. Intact classes were used in the sampled schools so as not to disrupt the normal school activities. Four weeks were used for the experiment. Each week had two periods (double periods each) of 40 minutes per period. The control group was taught using lecture method which involves lesson activities such as oral presentation of concepts, self-discovery and quantitative problem-solving which does not involve the students in chemistry-themed board games strategy. For the experimental class, the same set of activities for the control group was carried out for both double periods; but in addition to discussing and writing down their observations, students were engaged in such board games activities as:

a) *see-saw games*

A see-saw game is the board game of balance. It shows how equal two or more reactions could be. In this study, the game was used to demonstrate how reactants could be stable or balance with the products of an equation. The seesaw concept was used to illustrate the balance between the forward and reverse reactions in a dynamic equilibrium. The speed at which the seesaw returns to balance was used to represent how quickly the system reaches equilibrium. This was tied to the concepts of reaction rates and how different conditions like temperature, pressure, and concentration could affect the rate at which equilibrium is reached.

b) *Clinical interview and journal writing*

This was used by researchers to determine the interest of the students. It is a conversation of an expert with a student, focused by initial questions about the situations represented in series of line diagrams to check the student's interpretation of natural phenomena or social occurrence. It enables the students to interact closely with experts (the researcher). The students note their area of difficulty as the quizzes are going on.

The instrument used for data collection were the Chemical Equilibrium Achievement Test (CEAT) adopted from WAEC past Questions between 2017 – 2024 comprised 25 multiple-choice items with four options (prep-50). The items were selected according to the topics under treatment and options were reshuffled. The instruments were face and content validated by three experts and tested for reliability using Kuder-Richardson 20 (KR-20) which yielded a coefficient of 0.89. The instrument was firstly administered as pre-test, scored and kept without any feedback to the students. After the treatment, the same test with the same contents was reshuffled and given as post-test. Both tests were scored by the researcher to avoid bias. The results obtained were used for analysis. Research questions were answered using mean and standard deviation (SD) while the hypothesis were tested using Analysis of Covariates (ANCOVA).

Results

Research Question 1: What is the difference between the mean achievement and standard deviation scores of students taught Chemical equilibrium using chemistry-themed board games and those taught Chemical equilibrium using lecture method?

Table 1: Mean and Standard deviation of achievement scores of students taught Chemical equilibrium using chemistry-themed board games and those taught Chemical equilibrium using lecture method.

Teaching Strategy	Pretest			Posttest			Mean Gain
	N	Mean	SD	N	Mean	SD	
Game based instruction	48	27.46	11.96	48	67.00	12.25	39.54
Lecture method	52	27.08	10.67	52	55.12	14.21	28.04

Table 1 shows the pretest and posttest mean achievement scores of chemistry students taught chemical equilibrium with chemistry-themed board game based strategy were 27.46 and 67.00 while the gain in mean score was 39.54. Their counterpart taught using the lecture method had 27.08, 55.12 and 28.04 as pre-test, post-test and gain in mean scores respectively. This shows a 11.50 difference in gain in mean scores between the two groups in favor of the students taught with chemistry-themed game based strategy. The result also showed no remarkable difference in mean pretest scores between students in the two groups. This shows homogeneity amongst the students in the groups.

Hypotheses

H₁: There is significant difference in the mean achievement scores of chemistry students' taught chemical equilibrium using chemistry-themed board games and those taught with lecture method.

Table 2: Summary of Analysis of Covariance of effect of chemistry-themed board game based teaching strategy on students' achievement in chemistry by Treatment and Gender

Dependent Variable: Posttest							
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Squared	Eta
Corrected Model	5348.775 ^a	4	1337.194	8.186	.000	.256	
Intercept	35712.759	1	35712.759	218.631	.000	.697	
Pretest	1683.698	1	1683.698	10.307	.002	.098	
Strategy	3379.056	1	3379.056	20.686	.000*	.179	
Gender	313.342	1	313.342	1.918	.169	.020	
Strategy * Gender	30.734	1	30.734	.188	.665	.002	
Error	15517.985	95	163.347				
Total	390774.000	100					
Corrected Total	20866.760	99					

a. R Squared = .256 (Adjusted R Squared = .225)

Table 2 shows that at .05 level of significance, there was a significant main effect of the teaching strategy on students' academic achievement in chemistry concept of chemical equilibrium, $F(1, 95) = 20.686$, $P(.000) < .05$. Therefore, the research hypothesis was not rejected. Thus, there is significant difference in mean achievement scores of students taught chemistry concept of chemical equilibrium using chemistry-themed game based instructional strategy and those

taught using lecture method. The results showed favoritism with the group on chemistry-themed board game based instruction. Partial eta squared showed significant contribution of 17.9% achievement in the chemistry concept of chemical equilibrium resulting from chemistry-themed board game based instructional strategy.

Research Question 2: What is the difference between the mean achievement scores of male and female students taught Chemical equilibrium using chemistry-themed board games?

Table 3: Mean and Standard deviation of achievement scores of male and female chemistry students taught Chemical equilibrium using chemistry-themed board game based teaching strategy

Gender	Pretest			Posttest			
	N	Mean	SD	N	Mean	SD	Mean Gain
Male	23	30.87	13.37	23	65.83	12.19	34.96
Female	25	24.32	9.72	25	68.08	12.44	43.76

Table 3 shows the pretest and posttest mean achievement scores of male students (30.87 and 65.83) and their female counterpart (24.32 and 68.08) taught chemical equilibrium with chemistry-themed board game based teaching strategy. The gain in mean score for male students was 34.96 while that of the female counterpart was 43.76. This indicates a mean difference of 8.80 in favor of the female students.

H₂: There is significant difference in the mean achievement scores of male and female chemistry students' taught chemical equilibrium using chemistry-themed board games.

Table 2 shows that at .05 level of significance, there was no significant influence of gender on the effect of chemistry-themed board game based teaching strategy on students' academic achievement in chemistry concept of chemical equilibrium, $F(1,95) = 1.918$ $P(.169) > .05$. Therefore, the research hypothesis was rejected. Thus, gender has no significant influence on the academic achievement of students in Chemistry concept of chemical equilibrium. Partial eta squared showed insignificant contribution of 2% achievement in the chemistry concept of chemical equilibrium resulting from chemistry-themed board game based instructional strategy when moderating gender.

H₃: There is significant interaction effect of chemistry-themed board games and gender on the achievement of chemistry students'.

Table 2 further revealed that at .05 level of significance, there was no significant interaction effect of gender and the chemistry-themed board game based teaching strategy on students' academic achievement in chemistry, $F(1, 95) = .188$, $P(.665) > .05$. Therefore, the research hypothesis was rejected. Thus, there is no significant interaction effect of gender and the teaching strategy of chemistry-themed board game based learning on students' academic achievement in chemistry.

Discussion

The finding of the study revealed that there is significant difference in the achievement scores of the chemistry students taught chemical equilibrium with chemistry-themed board game based learning strategy and those taught using a lecture method; in favor of students' in game based teaching and learning strategy. The finding of the study is in consonance with Daubenfeld and Zenker (2015), Ookman (2016), Kavak and Yamak (2016); Stringfield and Kramer, (2014) who observed that game based teaching strategy had a significant effect on students' achievement in the selected Chemistry concepts. It was also discovered that chemistry-themed board based teaching strategy was more effective than the lecture method of teaching science in terms of students' overall achievement in Chemistry concepts and other science related subjects (Stojanovska, & Velevska, 2018). The finding was in agreement with Ausubel (1968), who demonstrated the efficacy of students' active participation in lessons through construction of their knowledge with game based instruction. The study's finding also revealed that there is no significant difference in the mean achievement scores of male and female students taught Chemistry concept of chemical equilibrium using game based learning strategy amongst students offering Chemistry in secondary school in Agbani Education Zone of Enugu State. The finding of the study is in agreement with Khan, Gul, Hussain and Yousaf (2022), Onah (2022), Onah and Achufusi (2022), who noted that gender, is not factor with teaching approach in science. The study on the hand showed that there is no remarkable relationship and interaction between gender and chemistry-themed board game based instructional strategy on students' academic achievement scores in chemistry. This finding was affirmed by the works of Khan, Gul, Hussain and Yousaf (2022), Onah (2022), who in their independent studies; found no evidence of a significant interaction between gender and instructional strategy on students' achievement in sciences. Onah and Nnadi (2022), on the other hand, observed a noteworthy interaction on students' academic progress in current electricity between gender and instructional treatment. The teaching strategy is a resounding approach as it showed no preference with gender. There is therefore a great need to embark on more studies in order to shed further light on the issue students' poor achievement that bedeviled the human capital development of the nation.

Conclusion/ Recommendations

Students' academic progress in chemical equilibrium has been increased by chemistry-themed board game based teaching strategy. This is because students' were actively involvement in the meaningful construction of knowledge through games. The strategy helped them to grasp the concept of chemical equilibrium and as such outperformed those who were taught the same concept through lecture in terms of posttest results. Nonetheless, the results indicated that there is no remarkable gender gap in students' academic achievement levels. Based on the findings of the study, the following recommendations were made:

- 1) Teacher education in universities and colleges of education should be focused on providing chemistry instructors with the knowledge and applicability of implementation of the chemistry-themed board game based teaching strategy in secondary school.
- 2) The Ministry of Education at all levels should empower chemistry teachers through seminar and workshop to employ game based teaching strategy as it is gender friendly.

- 3) The curriculum of teacher-training programs should include a course on the game based teaching strategy, through seminars, workshops, and other opportunities for working teachers to get refresher training on the method.
- 4) Curriculum planners should review the entire moribund curriculum in chemistry to include chemistry-themed board game based teaching strategy while authors of chemistry textbooks should integrate game based instruction to foster more achievement and gender equality.

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